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Design and Analysis of Aircraft Telescopic Wing and Material Optimization

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ABSTRACT: The development of morphing wing technologies for flight regime adaptation has received great interest from Researchers and engineers in the past years. This paper is in one such research where we have designed a morphing wing structure to our aircraft to adaptive mechanisms and structures. Morphing can encompass many aspects of the aircraft design, including the location, shape, area and angle of the wings, tail or fuselage. Our approach towards the work is to develop new concepts and technology thus enhances the overall flight performance of aircraft, enabling new approaches to the design of aircraft and improving multi-mission flexibility. We want to develop an aircraft with a morphing wing in a high-performance aircraft that can operate efficiently in multiple flight conditions by Changing in its material and thus finding the best material to improve overall performance.

Key words: Aircraft, optimization, telescopic wing, material

I. INTRODUCTION

Morphing changing ones image into another through a seamless transition. Morphing is generally achieved using either smart materials (materials which have one or more properties that can be significantly changed, in a controlled manner, by external stimuli), or structural morphing. The literature study of the paper through some of the resent designs shows that the morphable wing having more scope in the fields of improved aircraft performance for extent its flight envelope, extent performance reduced drag, vibration and improved range. Morphing changing ones image into another through a seamless transition. Morphing is generally achieved using either smart materials (materials which have one or more properties that can be significantly changed, in a controlled manner, by external stimuli), or structural morphing. And here we are using the composite material as the material for the wing design, large deformations of the morphing aircraft the orthotropic properties of composite material is used.

II. TELESCOPIC WING

External Telescoping Wing Section With Rectangular Platform

This concept involves rectangular inboard and outboard wing sections as shown in Figure, allowing for uniform cross sections within each wing segment. The outboard section must have a hollow cross section to allow the outboard section to slide over the inboard section. This will reduce the wing structural weight in the outboard section, but will also result in the outboard section having a greater chord than the inboard section. Consequently, the taper ratio for the entire wing would be greater than one, resulting in increased lift generation at the wingtip.

Internal Telescoping Wing Section With Rectangular Platform

This concept involves rectangular inboard and outboard wing sections shown in Figure, allowing for uniform cross sections within each wing segment. The inboard section must have a hollow cross section for the majority, if not the entire, inboard span. This arrangement allows the outboard section to retract within the inboard section and gives the overall wing platform a taper ratio of less than one due to the reduction of chord between the inboard and outboard sections required for structural supports. The hollow cross section of the inboard wing will result in reduced structural integrity.

Tapered Inboard Platform With Internal Telescoping Rectangular Wing Tip

This concept involves a tapered inboard section and a rectangular outboard wing section as shown in Figure, requiring varying cross sections within the inboard wing segment. The inboard section must have a hollow cross section for the majority, if not the entire, inboard span. This arrangement allows the outboard section to retract within the inboard section and gives an overall wing platform taper ratio of less than one. The hollow cross section of the inboard wing will result in reduced structural integrity. However, the increased root chord will improve the structural integrity of the wing. This wing will not benefit from the usual structural benefit of reducing weight towards

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the wing tip due to the structural reinforcement required for the telescoping outboard section.

WING MECHANISM

The wing mechanism conceptual design involved the development of the support structure for the outboard wing which involved the use of guide rails and rollers.

Rails

The choice of a mechanism that extends and retracts the wings and tail requires the use of a set of guide rails. Both square cross-section rails and circular cross-section rails were investigated. Square cross section rails provided an increased likelihood of the rails seizing under load if the rails were slightly misaligned. Additionally, it was found that square cross-section material was more difficult to source, which would make the procurement of the components more difficult.

III. LITERATURE REVIEW

Ever since the Wright Brothers first invented aircraft, they took inspiration from birds to create the machine capable of replicating their flight [1]. This design concept is followed today, and bird flight is deemed the most efficient flight [2] Hence, to achieve that, mainly two steps [3] are taken: firstly, the airplane body is made as smooth as possible to reduce drag. Secondly, the wings are made as efficient as possible in order for them to deliver lift efficiently at a range of velocities and flight conditions. However, traditional aircraft have not been able to achieve the ideal in both these aspects. As for the first aspect, aircraft bodies are not smooth enough to minimize interference drag, i.e., drag resulting from discontinuous interfering surfaces. Due to the nature of the materials used, aircraft bodies have imperfections and discontinuities, resulting in flow turbulization and additional drag [4]. Many developments have been made in wing morphing research recently [5,6], especially in the past twenty years. Therefore, a review was needed in order to highlight the breakthroughs. The performance and dynamic efficiency of an aircraft are significantly influenced by the aircraft shape and configuration. Therefore, the wing load response in terms of drag and lift has been given increasing attention through morphing technology [4].

Morphing aircrafts are flight vehicles that change their shape to effect both a change in the mission of the aircraft and to perform flight control without the use of conventional control surfaces. Aircrafts constructed with morphing technology promise the distinct advantages of being able to fly multiple types of missions, to perform radically new manoeuvres (not possible with conventional control surfaces), to be more fuel efficient and to provide a reduced radar signature. The key to morphing aircraft is the full integration of the shape control into the wing structure: a truly smart structure [7]. Mechanisms such as deployable flaps provide the current standard of adaptive aerofoil geometry, although this solution places limitations on manoeuvrability and efficiency, and produces a design that is non-optimal in many flight regimes. The development of new 'smart' materials, together with the always present need for better unmanned aerial vehicle performance is increasingly prompting designers towards the concept of morphing aircraft. These aircrafts possess the ability to adapt and optimize their shape to achieve multi-objective mission roles efficiently and effectively [7].

Other devices that are deployed when needed. The majority of aircrafts use these kinds of devices for specific flight phases, e.g. flaps are deployed for take-off and landing to increase lift at low speeds, by increasing the wing surface and changing its camber line: ailerons change wing twist angle to provide roll control and are used for all types of turns [8]. Whatever the type and age of the technology and whatever materials, actuators and structures it may use, the morphing aircraft technology significantly expands the aircraft flight envelope and/or improves its performance parameters at some, or all, flight conditions, when compared to a baseline conventional aircraft [9]. Morphing aircrafts can bring many advantages to aeronautical industries. Therefore, a lot of research in this area has been done. The latest research has been made on unmanned aerials vehicles with morphing technology and drones. These airplanes are easier to build, lighter and less complex, making them the perfect candidates for experiments, therefore increasing the interest and demand to universities and students. This type of aircraft is also suitable for research in the field of new material. As a result, testing of new structures and actuation mechanisms is in order, since they are lighter, reliable and stiffer [8]. Traditionally, Morphing Aircraft Technologies (MAT) are described, and divided, according to the morphing concept to which they are related to, which in turn are generally related to a particular geometrical change in the wing. Studies were made on the following morphing concepts/geometric parameters: twist, sweep, dihedral (folding and winglets), chord, span and camber. Major literature reviews can be found in Barbarino et al and Gomez et al. [10].

IV. RESULT AND DISCUSSION

CFD RESULT OF TELESCOPIC WING

Aluminium Deformation

The following results shows the total deformation analysis performed on telescopic wings made of Aluminium.Total deformation varies from 0 to 0.0066627 indicated by different colour indications from blue to red .blue region is of minium deformation and red region have a maximum deformation.

Aluminium Stress

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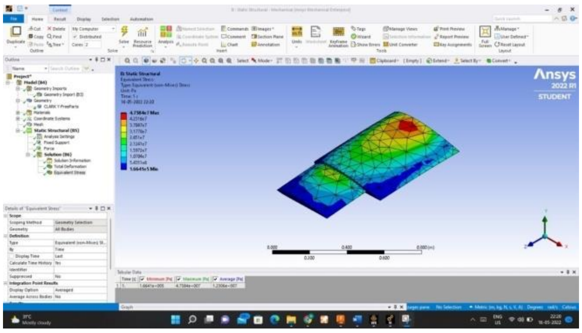

Figure 1 CFD results of a telescopic wing(stress)

This result show the equivalent stress analysis performed on the telescopic wing made of aluminium range from 1.6466e5Pa to 4.8142e7Pa. which is represented by colour indication to denote the stress effected zone over the surface of the wing blue to red.

E-glass Deformation

Total deformation when we use E-glass epoxy is less when compared to oyhermetal,hence it is one of the reason for choosing E-Glass epoxy for telescopic wing.

E-glass Stress

This result shows the equivalent stress analysis performed on the telescopic wing made of E-glass epoxy range from 1.6466e5 pa to 4.2811e7 pa which represented by colour indication to denote the stress effected zone over the surface of the wing from blue to red

E-glass UD Deformation

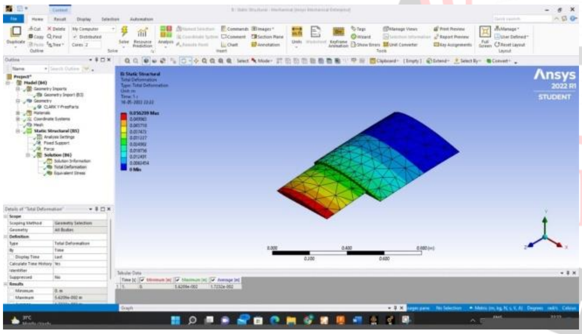

Figure 2 CFD results of E-glass UD

This results shows the total deformation analysis performed on telescopic wing made of E-glass UD ,the total deformation varies from 0 to 0.0526209 indicated by different colourfrom blue to red.blue region is of minium deformation , red have a maximum deformation.

Epoxy carbon –UD

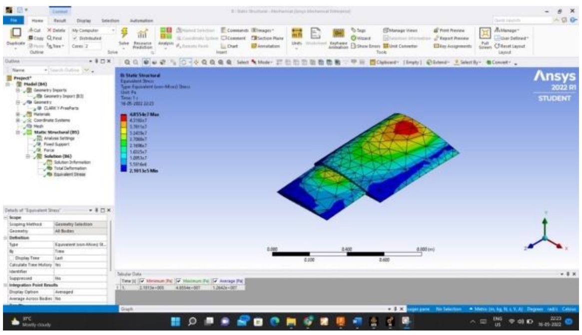

Fig 3 CFD results of Epoxy Carbon-UD

This result shows the equivalent stress analysis performed on the telescopic wing made of epoxy carbon UD range from 2.1013e5Pa to 4.8554e7Pa which represented by colour indication to denote the stress effected zone over the surface of the wing from blue to red.

Iterations

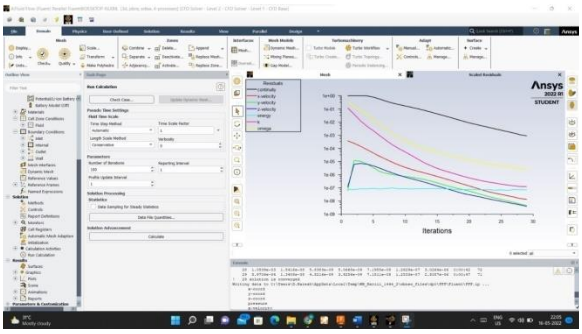

Fig 4 The iteration results of the e-glass/epoxy composites material

we give the maximum possible iteration number as 100,before it reaches 100 we get the solution, here we get the 29 as the solution.

A streamline is a line that is tangential to the instantaneous velocity direction. In streamline analysis and determines the velocity of flow over the surface of wings using colour indication from blue to red with varying velocity from 0.000e-1.209e m/s.

	Conventional wing		**Telescopic wing**	
Lift	2.3		2.8	
Drag	0.3		0.275	
Deformation	Aluminium (mm)	Composite (mm)	Aluminium (mm)	Composite (mm)
	2.5	.39	4.46	0.71

	Aluminium minimum	**Aluminium maximum**	**E-glass epoxy minimum**	**E-glass epoxy maximum**
Total Deformation(m)	0	0.0066627	0	0.0059332
Equivalent stress(Pa)	1.6641e5	4.7584e7	1.6466e5	4.8142e7

From the analysis we performed on Telescopic wings and normal wings with metals and composite materials we tabulated the results for lift drag and deformation.We can clearly see the deformation variations using Aluminium and E- glass epoxy. There is an advantage in lift and drag of air craft for normal wings and telescopic wings.When the telescopic wings are made of composite materials such as E galss epoxy we can get a better results in deformation,lift,drag...etc various

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Differences Between Aluminium And E-Glass Epoxy

Aluminium	E-Glass epoxy
It has a melting point of 660.3 °c	It has amelting point of2000 °c
It has a compressive strength of 24000psi	It has acompressive strength 300Mpa
It has a heardness of 1250Mpa	It has a hardness of 1350Mpa
It has a tensile strength 360Mpa	It has a tensile strength of 450Mpa
It has a Elastic limit of 280Mpa	It has a Elastic limit of 287.5Mpa

E-Glass epoxyshows better properties when subjected to loading conditions than aluminium it exhebitsbetter mechanical properties than aluminium which is more suitable for our current analysis .so , we choose E-Glass epoxy for our telescopic wing.

V. CONCLUSION

This report shows a highly positive image of telescopic wing, which is entirely justified in view of the numerous benefits offered by them.For large deformations of morphing aircraft the orthotropic properties of composite materials may be used. This may, for example, enable the elimination of hinges, which reduces the stress concentration around the pivot points, and consequently reduces the weight penalty introduced with morphing.Morphing technology allows the design of novel control effectors, often as a result of biological inspiration. From the equations, it is very complex and difficult to solve such equation series , because several parameters change with time.Hower, the model is versatile for any telescopic morphing aircraft, in some simple assumptions. This paper also bulid the model of rectangular telescopic wing with no sweep and dihedral. Some estimation formulae are applied to caLculate the aerodynamic force . Results show that at low velocity.high aspect ratio wing has better aerodynamic performance than low aspect ratio,while at high velocity low aspect ratio wing has superior performance. So, telescopic wing can enhance overall fight performance for a large velocit y range. The roll perfoamance also is evaluated by asymmetric wing span, aircraft can generate roll moment by change the stretching length of left and right wing. Results shows that roll moment coefficient varys evidently with difference value of telescopic wings' length and angle of attack. It is easy to controll the roll rate in this way. Moreover, roll performance of asymmetric wing is non-linear change

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In the result discussion we had discussed about the structural analysis of a telescopic wing with aluminium and e-glass epoxy material. The gathered result shows the increase in lift while using composite material in the wing .The conventional wing having the lift of 2.3 and drag of 0.3 the telescopic wing have the lift of 2.5 and the reduced drag of 0.275 and there is drastic change in the deformation of the wing for aluminium is 0.66627mm and for E-glass epoxy is 0.59332 mm under similar stressconditions and over all weight of aircraft can be reduced which can improve fuel consumption with an increased performance.

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